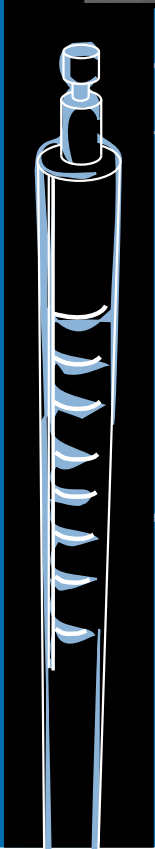
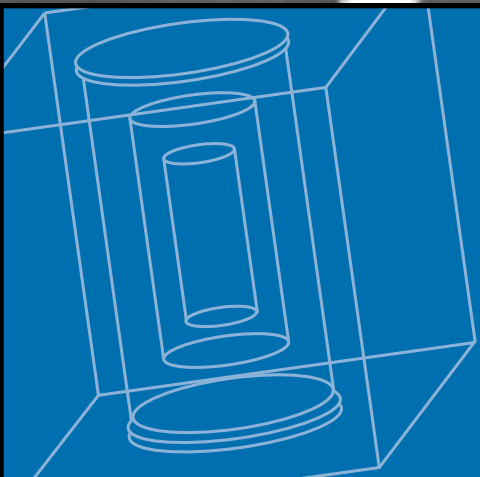
DOE/NE-0070

NUCLEAR POWERPLANT SAFETY:

Operations





NUCLEAR ENERGY

U.S. Department of Energy
Office of Nuclear Energy, Science, and Technology

On the cover:
Palo Verde Nuclear Reactor,
Arizona

Nuclear Powerplant Safety: Operations

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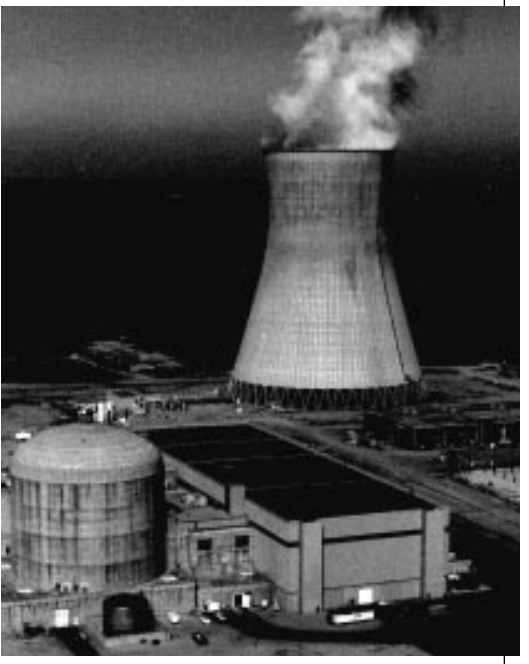
U.S. Department of Energy
Office of Nuclear Energy, Science, and Technology
Washington, D.C. 20585

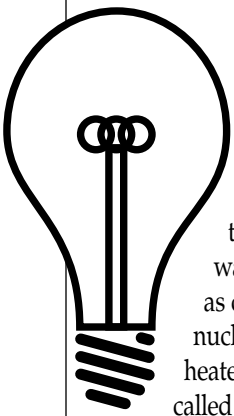
Nuclear Powerplant Safety: Operations

Nuclear powerplants are a major source of electricity in the United States and throughout most of the world. They generate about 20 percent of our nation's total electricity. Careful planning, good engineering and design, strict licensing and regulation, intensive training of operators, and thorough environmental monitoring help to ensure that nuclear powerplants operate safely. In fact, no powerplant accident has harmed a member of the public in the entire history of U.S. commercial nuclear power.



Hope Creek Generating Station, located along the Delaware River in Lower Alloways Creek Township, N.J. The reactor containment building is in the foreground. The cooling tower in the background emits steam from the cooling of water from the turbine.

How Nuclear Reactors Work



Both nuclear and non-nuclear powerplants produce electricity in much the same way. Water is heated and converted to steam, which in turn drives a turbine attached to a generator. In non-nuclear plants, the water is heated by fossil fuels such as coal, natural gas, or oil. In nuclear powerplants, the water is heated by the energy from a process called nuclear fission.

In the 1930s, scientists discovered that if they bombarded atoms of uranium with high-energy neutrons the uranium atoms would split apart, or fission. When this happens, they release excess energy as well as more neutrons, which can then strike other atoms and keep the fission process going. This chain reaction is the basis for nuclear powerplant operations.

For use as fuel in a reactor, uranium is formed into small pellets, which are stacked inside protective metal rods. Fuel rods are bundled together into fuel assemblies, which make up the reactor core. In addition to the fuel rods, there are other rods in the fuel assemblies which are made of a material which can absorb the neutrons. They are called the control rods, because they are used to control the rate at which the fission reaction takes place, or to stop it altogether.

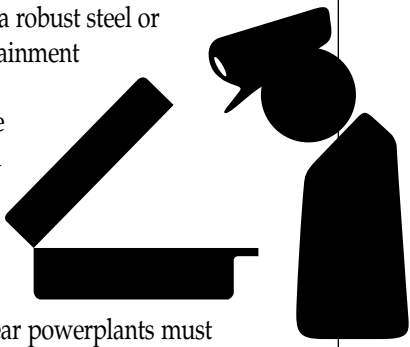
Operational Safety

When uranium atoms split, they give off radiation as well as heat. Radiation is a natural form of energy that has always existed on earth and throughout the universe. Although the term can include such forms of energy as light and radio waves, it usually refers to ionizing radiation. Ionizing radiation can change the chemical composition of many things, including living tissue. Therefore, we must limit our exposure to it.

The following measures help ensure that nuclear powerplants in the United States are operated to protect the health and safety of workers, the public, and the environment.

- State and Federal regulations limit the amount of radiation that nuclear powerplants are allowed to release.

- Multiple barriers protect against the release of radioactive materials, with the final barrier being a robust steel or concrete containment structure that surrounds the major portion of the nuclear system.



- All U.S. nuclear powerplants must be licensed by the Nuclear Regulatory Commission (NRC). The NRC is also responsible for inspection and enforcement, standards development, and research into what kind of regulations will best ensure safety.

- Powerplant personnel must establish programs and conduct audits, inspections, and environmental monitoring to ensure that the plants are operating safely and are in compliance with the limits on radioactive material releases.

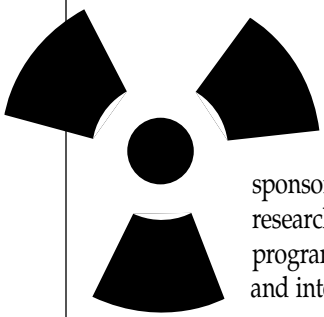
- Reactor operators are licensed by the NRC. They are thoroughly trained and periodically retrained on operating procedures.

- Powerplants must always maintain strict security to prevent the loss of nuclear materials and acts of sabotage.

- The transport and storage of spent nuclear fuel are strictly regulated.

The Role of the Nuclear Regulatory Commission

The NRC (formerly the Atomic Energy Commission) was created in 1974 by the Federal Energy Reorganization Act to regulate the basic functions of the nuclear power industry. The NRC establishes safety requirements, provides inspection and oversight, and sponsors ongoing safety research programs. These programs are both domestic and international in scope.



The NRC's Office of Nuclear Reactor Regulation is responsible for licensing all nuclear powerplants. In order to obtain a license, a

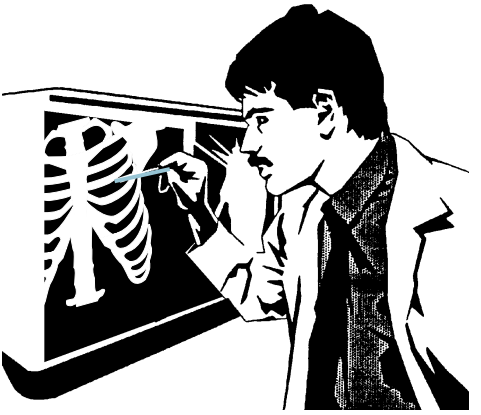
powerplant must provide detailed information to show that its design, construction, and operation will ensure safe conditions for workers and the public.

After licensing, the NRC's plant inspection program ensures continual attention to public health and safety, environmental protection, and security of nuclear materials and facilities. The NRC conducts routine inspections and investigates any accidents, unusual incidents, or even claims of unusual events that may occur during powerplant operation. Resident inspectors at each nuclear powerplant observe and monitor licensee activities and respond to operational events at the plant.

Violations of NRC requirements call for corrective actions and may result in heavy fines, plant closure, or suspending or revoking of the utility's operating license.

Control of Radioactive Material Releases

Releases of radioactive materials from nuclear powerplants could have harmful effects on



Sources of Radiation

Ra

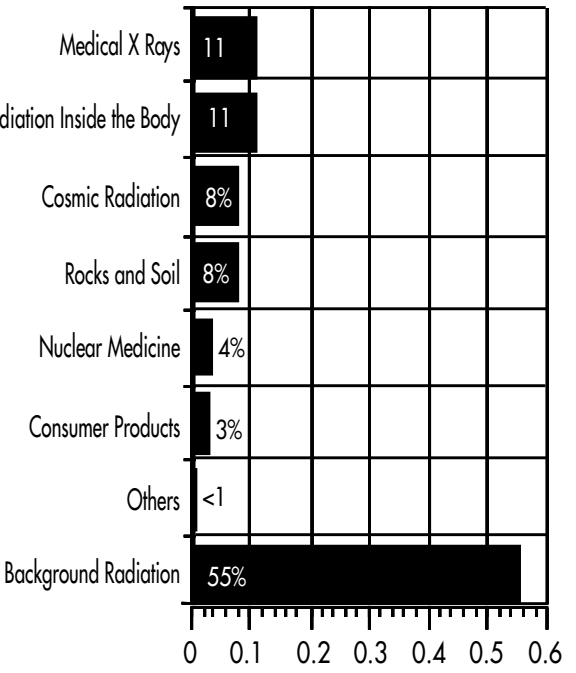
Natural

people and the environment. Utilities are required to monitor releases to the environment and ensure that they do not exceed limits established by the NRC.

Scientists measure radiation's effect on humans in units called rems. However, measuring the radiation emitted from powerplants in rems is like measuring the dimensions of a desk top in miles. It can be done, but it is not very practical. For that reason, the most commonly used unit to measure the radiation from a powerplant is the millirem (a millirem is one thousandth of a rem).

The average American receives about 360 millirem of radiation each year from both natural and man-made sources.

to the General Public



About 55 percent of this radiation comes from radon — a radioactive gas from the decay of naturally occurring uranium and thorium. The remaining portion comes from the earth's soil, food, and water, and from medical applications. A very small fraction comes from various other sources, including nuclear powerplants. Less than one-tenth of one percent of the average American's exposure to radiation comes from the nuclear power industry.

NRC regulations state that people who live near a nuclear powerplant cannot be exposed to more than 100 millirem of radiation from that facility annually. Operating data show that powerplants expose their neighbors to far less than 1 millirem per year.

Personnel Training Programs

To train their operators, the utilities use exact mockups of an actual powerplant control room. These simulators are computer controlled like the ones pilots use in flight training. They allow the operators to gain practical experience in managing all types of normal and unusual situations without affecting the plant. The operators react to simulated plant functions, using operating procedures. Instructors discuss the best actions to take in given situations.

The Institute of Nuclear Power Operations (INPO), an organization supported by the utility industry, conducts detailed evaluations of operating practices at all nuclear powerplants. The U.S. Department of Energy (DOE), INPO, and the NRC work together to upgrade the training of reactor operators. The recommendations from DOE and INPO supplement NRC's requirements and help utilities achieve very high standards for selecting and training the people who operate the plants.

Plant Operators

The powerplant staff is highly qualified, skilled, and trained in reactor operations and safety. Operators and senior operators are required to be licensed by the NRC for that particular facility. The operator works the controls of the facility. The senior operator has the additional responsibility of directing the activities of the other licensed operators.

Hope Creek station control room

At least one Licensed Senior Reactor Operator, two Licensed Reactor Operators, and two Unlicensed Plant Operators must be present during each working shift at a nuclear powerplant. In addition, a technical adviser, who is usually a graduate engineer, provides advanced technical help and information for both normal and unexpected conditions.

Operator licenses are granted only to qualified personnel who must demonstrate a high degree of proficiency and pass in-depth examinations (written and oral) on plant operations and safety. All licensed operators must complete periodic retraining courses to keep their skills at the highest levels. This retraining consists of classroom lectures, drills, and exercises with a control room simulator.

Nuclear Powerplant Emergency Plans

Every nuclear powerplant has to have an emergency plan for dealing with any unexpected event that could affect public health and safety. Utilities also conduct periodic exercises and drills to ensure that all personnel know what to do in case of an onsite or offsite emergency. These activities are coordinated with other Federal, state, and local agencies.

Nuclear Powerplant Security

Nuclear powerplants always maintain strict security to help ensure their operating safety and protect against the loss of nuclear materials or acts of sabotage that could cause an unplanned release of radioactive material. Commercial nuclear powerplants employ well trained security forces, set up physical barriers and elaborate electronic surveillance systems, and screen visitors to keep unauthorized persons from entering the site.

Spent Fuel — Handle With Care

For a nuclear powerplant to operate efficiently, part of its nuclear fuel must be periodically replaced with new fuel. Upon removal from the reactor, this highly radioactive spent fuel, or high-level waste, must be handled with care. Plant personnel transfer the spent fuel to a 30-foot-deep pool of water within the powerplant. The water removes heat from the spent fuel and serves as a radiation shield. Although the present method of storing spent fuel has been proven safe, available storage space is filling up.

The Department of Energy (DOE) is working closely with industry to find the best solution to this problem. Using existing technology, it is possible to design, construct, and safely operate a high-level waste repository. The DOE is currently studying Yucca Mountain in Nevada to determine whether it is a suitable location for permanent storage of this high-level waste.

Shipping Spent Fuel

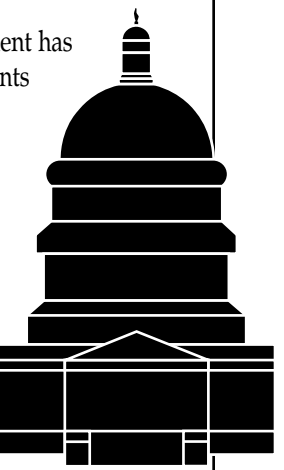
Disposing of spent fuel requires shipping it from one point to another. There are certain risks involved in shipping radioactive waste, such as theft or release of radioactive material due to a transportation accident.

Heavy-duty shipping containers and highly trained security personnel help prevent theft and accidental releases. Shipping containers have been tested in collisions up to 80 miles per hour, immersed in water, placed in fires, and dropped on hard surfaces and steel bars. In all of the tests, the damage that the containers received would not have permitted the release of any radioactive material. In the long history of transporting spent fuel, there has never been an accident that released radioactive material.

Operational Safety — A Continuing Commitment

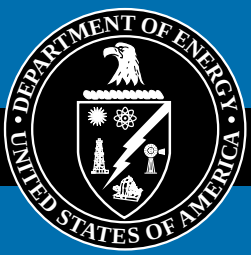
Each aspect of a nuclear powerplant's design, construction, operation, and security reinforces its overall operational safety. Every nuclear powerplant has to be licensed by the NRC. Ongoing NRC oversight ensures that the plant continues to be operated safely and in compliance with the regulations and the requirements set forth in the facility license.

In recent years, the government has further upgraded requirements for safety as a result of new information from ongoing research programs and operating experience. As a result of this careful approach and ongoing commitment, nuclear power production in the U.S. has an excellent safety record.



The Department of Energy produces publications to fulfill a statutory mandate to disseminate information to the public on all energy sources and energy conservation technologies. These materials are for public use and do not purport to present an exhaustive treatment of the subject matter.

This is one in a series of publications on nuclear energy.



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